

## LOW EMISSION FIBROUS WEBS AND METHOD OF SUCH WEBS

5           This invention involves webs of polymer fibers containing latex binder modified with formaldehyde containing crosslinkers in which the formaldehyde component is chemically bound and that display substantially reduced formaldehyde emissions during the drying, curing and further processing and storing of the webs. The webs of the invention also have good hot strength. The invention also involves the method of making polymer fiber webs  
10       having substantially lower formaldehyde emissions and substantially lower formaldehyde emissions when later processed at elevated temperatures to produce other products like asphaltic roofing products.

### Background

15           It is known to make polymer fibrous mats for use in making asphaltic and modified asphaltic roofing products like roll roofing products by bonding inorganic fibers or polymer together with a latex binder such as an SBR or acrylic type latex containing crosslinking ingredients that emit formaldehyde when dried and cured at an elevated temperature and  
20       when later processed with hot asphaltic material to make roofing products, or when subjected to hot, humid conditions. Such ingredients are crosslinking agents employed to improve cured physical binder properties through functional groups, usually incorporated into the latex polymer backbone by copolymerization of N-methylol acrylamide, N-methylol methacrylamide, or the addition of resins that contain N-methylol functional groups that are  
25       either chemically blocked or unblocked. Also, other binders including melamine formaldehyde resin mixed with copolymers of styrene, butadiene, acrylic acid and acrylamide and other catalysts and functional additives have been used as a binder in spunbond roofing webs. The resin binders provide Thermal Dimensional Stability to the webs to reduce stretching in the machine direction and cross machine direction shrinkage,  
30       necking down, when the webs are impregnated or coated with hot asphalt. Such a process and products are disclosed in United States Patent Nos. 3,967,032, 4,125,663. A disadvantage of these binders and products is that they emit formaldehyde vapors when heated in the drying and curing operation during manufacturing of the Spunbond webs or by hot asphalt.

35           It is also known to add certain known formaldehyde scavengers to binders containing resins that contain formaldehyde to reduce emissions. United States Pat. No. 5,578,371

teaches adding urea, melamine, dicyandiamide and/ or 1-10 wt. percent of a water-soluble bisulfite or precursor to urea extended phenol formaldehyde binders in the manufacture of fiber glass insulation products, which products are not later coated or impregnated with hot asphalt.

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United States Pat. No. 5,795,933 also teaches adding a bisulfite such as sodium bisulfite, ammonium bisulfite or calcium bisulfite as a formaldehyde scavenger to an urea extended phenolic resin systems employing amino-group-containing formaldehyde scavengers in the manufacture of glass fiber products like thermal insulation.

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United States Pat. No. 5,160,679 teaches using acetoacetamide as an effective formaldehyde scavenger in the manufacture of wood particleboard and durable press finished fabrics that use urea formaldehyde as a binder. United States Pat. No. teaches using such formaldehyde scavengers as diethylene glycol, sorbitol, urea, melamine, diazine, triazine, and a water-soluble active methylene compound in the manufacture of durable press finished fabrics and wood particleboard.

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United States Pat. No. 5,612,405 teaches glass fiber products bonded with a binder containing an aqueous compatible formaldehyde resin like phenolic resin, an aqueous latex elastomeric polymer like styrene butadiene, ethylene propylene monomer, ethylene propylene-diene terpolymer, etc., an acrylic polymer like copolymers of acrylic acid, methacrylic acid acrylic or methacrylic acid esters from 1-4 carbon atoms, acrylamide polymers or copolymers and esters thereof of from 1-4 carbon atoms, and a formaldehyde scavenger like melamine, guanamine, benzyl guanamine, guanidine, dicyandiamide, and the like.

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United States Pat. No. 5,719,228 teaches using furan resins to bond glass fibers together to manufacture glass fiber products and to add urea or ammonia as formaldehyde scavengers, but also teach that these known additives produce disadvantages and therefore prefer to prereact an acidic furan resin, a formaldehyde scavenger and a source of reactable formaldehyde with a source of ammonia before spraying the binder onto the glass fibers.

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United States Patent No. 5,795,933 teaches aqueous metal coating compositions comprising a formaldehyde containing resin and a formaldehyde scavenger consisting essentially of an organic compound having at least one active methylene hydrogen and a pKa about 5 to 13.

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United States Pat. No. 5,143,954 teaches a low formaldehyde, self-cross linking polymer latex composition for use in making nonwoven products, the composition including one or more very complex and costly formaldehyde scavengers such as N-hydroxyethylethyleneurea, ethyl acetoacetate, 2,4-pentanedione, esters of 2-cyanoacetate, 2-cyanoacetamide, trimethylopropane tricyanoacetate, and the polymerized residue of methacryloxyethyleneurea.

As the above patents indicate, a tremendous effort has been made to suppress the emissions of formaldehyde from various products containing formaldehyde containing resins as a binder, but as yet no effective solution has been known for achieving a formaldehyde resin bound spunbonded web having low formaldehyde emissions during the drying and curing operation of manufacturing the Spunbond web or when contacted with hot asphalt in the manufacture of roofing and similar products. This is the problem solved by the invention described below.

### **Brief Summary of the Invention**

The present invention also includes a nonwoven web of polymer fibers bonded with from about 5 to about 30 wt. percent of a cured binder composition, preferably from about 16 to about 24 wt. percent and most preferably from about 18 to about 22 wt. percent, based on the weight of the web or mat. The resin component of the binder is of a type that will emit formaldehyde when exposed to the high temperatures of drying and curing or to hot asphalt conditions, such as resins having reasonably good elasticity such as formaldehyde fortified, styrene-butadiene- acrylonitrile, acrylic and similar type resins. The binder is preferably a mixture of copolymers, like GenCryl® 9030 available from Omnova Solutions, Inc. of Chester, SC. By fortified is meant that formaldehyde is incorporated into the polymer to provide high temperature strength. The binder can also contain trace amounts of free acrylamide, acrylonitrile, butadiene, formaldehyde, methanol, styrene and 4-vinylcyclohexene. The basis weight of the web can be any conventional weight but normally is in the range of about 50 to about 250 gms/sq. meter, more typically about 100-225 and preferably about 150-200, such as about 175 gms/sq. meter. The latex may be a polymer composed of ethylene-vinyl acetate copolymer, styrene-acrylic copolymer, vinyl-acrylic copolymer, styrene-butadiene-acrylonitrile copolymer, or acrylic copolymer.

The web is a spunbonded web of polymer, such as polyester, fibers bound together with a resinous binder except that in place of prior art binders, the binder contains one or more formaldehyde fortified polymer resins that normally emit substantial formaldehyde at high

temperatures, but in this invention the binder also contains a bisulfite compound, preferably ammonium bisulfite, added in amounts from at least about 0.75 wt. percent up to about 7.5 wt. percent (dry weight basis of the binder). This binder is applied in latex form to the fibrous web after the fibers are made and collected in a known manner and then the wet web is dried and heated to cure the binder in a known manner. The resultant nonwoven webs have good hot strength and low formaldehyde emissions and reasonable costs, something not heretofore attainable with these types of formaldehyde containing latex binders. The webs of the present invention are useful as substrates in known processes for making various roofing products such as built up roofing products and for other known uses in which polymer fiber webs are used.

The method of making the inventive webs is also part of the present invention. This method comprises melting a polymer, converting the melt to fibers, attenuating the fibers to the desired fiber diameter, collecting the fibers in a random pattern on a collecting surface, applying a formaldehyde containing latex resin binder to the web in an amount that the binder content of the dry web will be in the range of about 5-30 wt. percent, based on the weight of the dry web, and drying the web and curing the resin binder to bond the polymer fibers together to form a nonwoven polymer fiber web, the improvement comprising adding about 0.75-7.5 wt. percent, based on the dry weight of the formaldehyde containing resin, of a bisulfite compound to the latex binder before applying the latex binder to the collected polymer fibers.

The above inventive binder composition produces webs that reduce formaldehyde emissions by more than 25 percent, preferably at least 50 percent and most preferably about 90 percent, compared to a prior art web bound with the same resin, but not containing the bisulfite addition, when the webs are heated to 200 degrees Centigrade., a temperature expected in the drying and curing operation of manufacturing the web or when subjected to hot asphalt. This reduction of formaldehyde allows the use of preferred binding resins that contain formaldehyde while avoiding the need for costly investment in thermal or catalytic incinerators or other emission abatement equipment and their operation in both the web manufacturing plant and in the roofing plants where the webs are used.

When the word "about" is used herein it is meant that the amount or condition it modifies can vary some beyond that so long as the advantages of the invention are realized. Practically, there is rarely the time or resources available to very precisely determine the limits of all the parameters of ones invention because to do would require an effort far

greater than can be justified at the time the invention is being developed to a commercial reality.

The skilled artisan understands this and expects that the disclosed results of the invention might extend, at least somewhat, beyond one or more of the limits disclosed. Later, having the benefit of the inventors disclosure and understanding the inventive concept and embodiments disclosed including the best mode known to the inventor, the inventor and others can, without inventive effort, explore beyond the limits disclosed to determine if the invention is realized beyond those limits and, when embodiments are found to be without any unexpected characteristics, those embodiments are within the meaning of the term about as used herein. It is not difficult for the artisan or others to determine whether such an embodiment is either as expected or, because of either a break in the continuity of results or one or more features that are significantly better than reported by the inventor, is surprising and thus an unobvious teaching leading to a further advance in the art.

### **Detailed Description of Preferred Embodiments**

The polymer fiber webs of the present invention can be formed by many known processes for making polymer fiber webs, but a typical preferred process is disclosed in United States Patent No. 4,163,305, which reference is incorporated herein by reference. After the fibers, which can be any known polymer fiber, but are preferably polyester fibers, are collected in a nonwoven form on a collection surface such as a permeable conveyor belt or chain, the web is passed through a binder applicator section where an aqueous latex binder is applied in any conventional manner in the amount desired. The wet, bindered web is then passed through a hot oven to dry the web and to cure the resinous latex binder.

The binders used to make the webs of the present invention are water-based latexes containing one or more polymer resins and a bisulfite, preferably ammonium bisulfite. The bisulfite is present in amounts from about 0.75 wt. percent to about 7.5 wt. percent, based on the dry weight of the resin. Typically the bisulfite is added in an aqueous solution in a concentration of about 60 wt. percent, but it can be added in other well known forms so long as it dissolves in the binder latex.

The resin used is a resin that is a latex polymer composed of ethylene-vinyl acetate copolymer, styrene-acrylic copolymer, vinyl-acrylic copolymer, styrene-butadiene-acrylonitrile copolymer, or acrylic copolymer. The various copolymers may be prepared by emulsion polymerization of one or more acrylic ester monomers including ethyl acrylate,

methyl acrylate, methyl methacrylate, butyl acrylate, 2-ethyl hexylacrylate, hydroxyethyl acrylate, hydroxypropyl acrylate, and hydroxyethyl methacrylate; acrylamide or substituted acrylamides; butadiene; styrene ; acrylonitrile; vinyl acetate or other vinyl esters; carboxylic acid monomers or ethylenically unsaturated anhydrides which can generate carboxylic acids. The latex polymer will have an internal N-methylol crosslinker such as of N-methylol acrylamide, N-methylol methacrylamide, or added resins that contain N-methylol functional groups that are either chemically blocked or unblocked.

These types of resin all emit significant amounts of formaldehyde when heated to high temperatures, such as the conditions in the drying and curing operation of manufacturing the webs or when contacted with hot, molten asphalt in typical roll roofing (Built-Up-Roofing products) manufacturing processes. These resins are typically fortified SBR, acrylic and resins having similar properties as these resins. A preferred resin is known as G-9030 available from Omnova Solutions, Inc. of Chester, SC. This material is a styrene-butadiene-acrylonitrile type latex having the following characteristics:

Active solids concentration in water 50%  
Ph – about 7.5  
Specific Gravity – 1.08  
Volatile organic content (VOC) < 0.1%

Any type of polymer fibers can be used in the webs of the present invention depending upon the desired properties of the webs and the intended applications as is well known to the artisan. When making webs for use in making roofing products spunbond polyester fibers are preferred. The following examples demonstrate the problems solved by the present invention, some of the preferred embodiments and the most preferred embodiment, and demonstrate only a few of the many possible embodiments of the present invention.

### Example 1

A polyester spunbonded mat was made in a known manner such as the process described in U. S. Patent No. 4,125,663, the disclosure hereby incorporated herein by reference, in which the binder used to bond the polyester fibers together was GenCryl® 9000, an emulsified styrene butadiene acrylonitrile copolymer latex binder containing very little formaldehyde, available from Omnova Solutions, Inc. of Chester, SC. This binder did not contain a bisulfite addition. The binder content was 20 wt. percent in the finished dry mat, based on the weight of the dry mat. The properties of this mat are shown in Table 1 below.

## Example 2

A second polyester spunbond mat was made in the same process as the mat made in Example 1 above except the binder used was GenCryl® 9030, the high performance mixed polymer latex type binder with a 50 percent concentration in water and available from Omnova Solutions, Inc. This binder is described above in detail. The binder content in the mat made in this example was about 18 wt. percent. By high performance binder is meant that the binder contains N-methylol functionality and as such exhibits improved high temperature performance characteristics when subjected to temperatures of hot asphalt, 200 degrees centigrade. . No addition of bisulfite was made to this binder. The properties of this mat are shown in Table 1 below.

## Example 3

Another web was made using the process used in Example 1 except that 2.5 wt. percent of ammonium bisulfite (60% concentration in water), based on the dry weight of the binder, was added to the high performance GenCryl® G-9030 binder containing formaldehyde used in Example 2 above. These properties of this finished mat are compared with the properties of the mats made in Examples 1 and 2 in Table 1.

Table 1

Properties	Example 1	Example 2	Example 3
Binder Content (wt. %)	20	18	18
Basis wt. (gms/sq. meter)	173	174	172
Thickness (mm)	0.95	1.01	1.00
Tensile strength (lb./in.)			
Machine Direction	72	79	75
Cross Machine Dir.	46	44	42
Elongation (%)			
Machine Direction	31	30	30
Cross Machine Dir.	33	34	33
Shrinkage @ 200 deg. C.(%)			
Machine Direction	0.90	0.93	0.94
Cross Machine Dir.	-0.30	-.20	-0.22
Tear Strength (lbs.)			
Machine Direction	32	32	31
Cross Machine Dir.	23	23	23

TDS\* @ 200 deg. C. (%)

Machine Direction	1.5	1.0	1.0
Cross Machine Dir.	-1.6	-1.2	-1.3

5	Tube Furnace Emissions (ppm formaldehyde)** -	1400	16,333	4628
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\* Thermal Dimensional Stability (Description of test given below).

\*\* binder heated to 200 deg. C. and exhaust gas analyzed.

10 Thermal Dimensional Stability is a characteristic that is very important in the use of nonwoven polymer fiber mats in the manufacture of roofing products. As discussed above in the background, polymer fiber mats tend to stretch in the machine direction and neck down, shrink, in the cross machine direction when coated or impregnated with hot, molten, asphalt or modified asphalt material. This stretching and particularly the necking down in

15 the cross machine direction requires the use of a wider mat to compensate and to insure the final dimension of the roofing product. Wider mats are often much more costly because the machine making the mats is limited in width and as much as 20-50% productivity can be lost when making a wider mat.

20 The test for Thermal Dimensional Stability is as follows. Three test samples measuring 350 mm in the machine direction of the mat and 100 mm in the cross machine direction are cut from the mat with a specimen being taken 100 mm from each side of the mat and the third sample taken from the center portion of the mat. A line is drawn across one surface of each of the samples 50 mm on each side of and parallel to the lengthwise

25 centerline of the sample using a material that will still be visible after heating to 200 degrees C. Each sample is mounted on a stand with a preheated clamp that allows each sample to hang vertically in a furnace with a four kg weight attached to the bottom clamp on the sample to provide stress on the sample similar to the stress on the mat in the roofing product manufacturing process. Clamps attaching to each sample are preheated for five

30 minutes at 200 degrees Centigrade in the oven, removed and attached to the samples and placed back into the 200 degree oven for five minutes, then removed and allowed to cool under stress for five minutes. The distance between the marks made on each sample is measured as is the width of the sample at the lengthwise centerline and the amount of change calculated. The three machine direction results are averaged to give the machine

35 direction percent change and the three width or cross machine direction results are averaged to give the cross machine direction percent change. Values of 1.0% or less are highly desirable.



The nonwoven web or mat of Example 1 has been used to make roofing products. It has acceptable formaldehyde emissions in the drying and curing section of the web manufacturing process or hot asphalt coating operation, but it produces lower performance in hot elongation in the roofing manufacturing process than desired as indicated by the TDS results, i. e. more than desired stretching in the machine direction and necking down in the cross machine direction. The nonwoven mat of Example 2 had about 33% improvement in the TDS test compared to that of Example 1, an acceptable hot strength, but the formaldehyde emissions at elevated temperature was unacceptably high.

The addition of a bisulfite is effective in lowering formaldehyde emissions at elevated temperatures in amounts as low as 0.75 wt. percent based on the dry weight of the formaldehyde resin in the latex. Table 2 shows the effect of ammonium bisulfite concentration in the G – 9030 latex binder in webs made using the method of Example 3, but varying the amount of ammonium bisulfite addition to the binder before applying the binder latex to the polyester web.

**Table 2**

<b>Amount of Bisulfite Compound Added</b>					
<b>Tube Furnace Results:</b>	<b>0%</b>	<b>0.75%</b>	<b>1.25%</b>	<b>2.5%</b>	<b>5%</b>
Emissions (ppm CH <sub>2</sub> O)	16,333	12,000	8085	4630	1265

The bisulfite compound is useful up to about 7.5 wt. percent to reduce emissions, but above about 7.5 percent the bisulfite begins to degrade the properties of the webs. While ammonium bisulfite is the preferred additive, the bisulfite can be any bisulfite material such as sodium bisulfite, calcium bisulfite, etc.

The preferred embodiments described above are only a few of the many embodiments possible as will be readily recognized by a person of ordinary skill in this art given the above disclosure. These and obvious modifications thereof are intended to be included in the following claims.